Medication Safety

Adopting Real-Time Surveillance Dashboards as a Component of an Enterprisewide Medication Safety Strategy

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The adverse drug event (ADE) literature during the past two decades has referred to the magnitude of injury[1,2] and the cost to society[3,4] and has led to a call to action.[5] In addition, The Joint Commission has promulgated National Patient Safety Goal 3 ("Improve the safety of using medications").[6] Researchers have measured ADEs in different patient populations[7] and health care environments[8] and have highlighted the need for feedback to manufacturers and regulatory agencies.[9,10] Throughout this period, computerized surveillance methods have been developed[11,12] to augment voluntary reporting with automated detection methods and to provide a framework for action.[12–14] The challenge remains for health care organizations to integrate surveillance methods into their clinical practice to identify potential signals and trigger an intervention that is sufficiently timely to prevent or ameliorate ADEs.

In 2006, Vanderbilt University Medical Center (VUMC; Nashville, Tennessee) set strategic quality objectives to reduce ADEs and medication errors. Institutional teams conducted retrospective reviews of the following high-risk medications and their corresponding laboratory-monitored ADEs: warfarin, enoxaparin, and heparin (excessive anticoagulation); and aminoglycoside antibiotics (nephrotoxicity). On the basis of the finding of apparently preventable ADEs among these high-alert medications, we [that is, all the authors] developed real-time monitoring and surveillance tools, which were designed to identify patients at increased risk of an ADE.

Although the VUMC ADE committee included both adult and pediatric hospital representatives, initial development was targeted toward the adult population, which had significantly greater use of high risk medications. We designed and implemented a surveillance tool with dashboards for monitoring aminoglycosides, warfarin, and anticoagulants (heparin and enoxaparin) by clinical pharmacists. The surveillance tools operated independently of computerizer provider order entry (CPOE) and existing clinical decision support (CDS) but were designed to be complementary by serving as a final safety net to

Article-at-a-Glance

Background: High-alert medications are frequently responsible for adverse drug events and present significant hazards to inpatients, despite technical improvements in the way they are ordered, dispensed, and administered.

Methods: A real-time surveillance application was designed and implemented to enable pharmacy review of high-alert medication orders to complement existing computerized provider order entry and integrated clinical decision support systems in a tertiary care hospital. The surveillance tool integrated real-time data from multiple clinical systems and applied logical criteria to highlight potentially high-risk scenarios. Use of the surveillance system for adult inpatients was analyzed for warfarin, heparin and enoxaparin, and aminoglycoside antibiotics.

Results: Among 28,929 hospitalizations during the study period, patients eligible to appear on a dashboard included 2,224 exposed to warfarin, 8,383 to heparin or enoxaparin, and 893 to aminoglycosides. Clinical pharmacists reviewed the warfarin and aminoglycoside dashboards during 100% of the days in the study period—and the heparin/enoxaparin dashboard during 71% of the days. Displayed alert conditions ranged from common events, such as 55% of patients receiving aminoglycosides were missing a baseline creatinine, to rare events, such as 0.1% of patients exposed to heparin were given a bolus greater than 10,000 units. On the basis of interpharmacist communication and electronic medical record notes recorded within the dashboards, interventions to prevent further patient harm were frequent.

Conclusions: Even in an environment with sophisticated computerized provider order entry and clinical decision support systems, real-time pharmacy surveillance of high-alert medications provides an important platform for intercepting medication errors and optimizing therapy.

intercept medication errors.

Two key observations motivated the development of the surveillance tool. First, the effectiveness of CDS systems is limited by the complexity of the underlying patient conditions, the immaturity of interfaces to enable high-quality human-computer interaction, and the difficulty in providing computerized decision support to influence decisions made by care teams.[15,16] Second, nearly all frontline safety mechanisms can be overridden by providers to support exceptional circumstances. Distinguishing appropriate overrides from medication errors requires expert review of the clinical context; reviews that are performed are often retrospective and too late to affect clinical care.

Real-time surveillance dashboards complement existing decision support mechanisms,[17–20] synthesize patient data for a evaluation by a context expert, and serve as an additional check to prevent propagation of errors within high-alert medication orders and ensure timely monitoring. In this article, we describe the surveillance tool's design, development process, implementation, and initial usage evaluation and discuss how such tools can be integrated into clinical pharmacy practice.

Methods

Surveillance Tool Design

The surveillance tool is a Web application that organizes patient data onto dashboards on the basis of provider-entered orders for high-alert medications. Messages from clinical and administrative systems are parsed and stored in a relational database. Scheduled tasks analyze new data for patient eligibility, calculate alerts, and compile the appropriate patient characteristics for the dashboards. All user activity is logged into the database.

Authenticated users initially see a summary page listing all dashboards for the adult Vanderbilt University Hospital (VUH), the pediatric Vanderbilt Children's Hospital (VCH), and new dashboards under development (Appendix 1, available in online article). A screenshot of the aminoglycoside dashboard, which displays all patients with an active order for an aminoglycoside (gentamicin, tobramycin, or amikacin), is shown in Appendix 2 (available in online article). Alert conditions are shown in the left-most column. From this dashboard, the user can click on the patient's name for a more detailed view of the patient's record, which integrates orders, laboratory results, demographics, and medication administrations in tabular and graphical forms. Appendix 3 (available in online article) shows this view for a patient on the warfarin dashboard, with Appendix 4 (available in online article) illustrating the graph component. From either the dashboard or patient view, the reviewer can flag panels or patients as "checked" (Appendix 2 and Appendix 3) by clicking the "This Page Last Checked" or the "Last Checked" cell for each patient's record. The "checked" feature was used to denote that the patient's case was reviewed in detail that day.

Reviewers can launch CPOE directly via a hyperlink to adjust/enter orders, create interpharmacist communications (comments), and author official pharmacy recommendations into the electronic medical record (EMR) using a template that incorporates basic data from the tool (labeled "Star Comments" in Appendix 3). The interpharmacist comments entered from the patient view can be reviewed from the dashboard (Appendix 2) by using the mouse to hover over the comments ("Com") column.

Configuration of Dashboards. Dashboards are configured in the following three steps:

1. Specify enrollment criteria, including the drug exposures or laboratory results, that determine when a patient populates a dashboard, as well as how long after exposure the patient remains on the dashboard.

2. Select data types and column organization to be displayed on the summary and patient view pages.

3. Define alert conditions—laboratory results, orders, or the absence of monitoring. Complex alerts are represented as functions in the Python programming language (Python Software Foundation; http://www.python.org/).

Alerts. Three alerts were created for the warfarin dashboard, six for the aminoglycoside dashboard, and seven for the heparin/enoxaparin dashboard (Table 1, page 328).

Analysis and Outcomes

We analyzed usage of the adult aminoglycoside, heparin/enoxaparin, and warfarin dashboards for a six-month period (April 2009–September 2009). For each hospital patient encounter or "case," we calculated exposure to medication orders and alert criteria. A patient readmitted at a later date would be counted as a new case. We also measured the average daily census on the dashboards.

We evaluated system utilization by examining user log data for each dashboard, excluding activity by nonclinicians (for example, system developers and administrators).

Dashboard Coverage. We first evaluated dashboard coverage in terms of the following three outcomes:

1. The number of distinct pharmacist users for the dashboard
2. The number of days of dashboard use by the top three users
3. The peak hours during which more than 90% of the dashboard review occurred

Dashboard Utilization. To evaluate utilization, we measured the following four outcomes:

Table 1. Alerts for the Warfarin, Aminoglycoside, and Heparin/Enoxaparin Dashboards

Warfarin Dashboard
1. High INR: The international normalized ratio measurement of prothrombin time (INR) is greater than 3.0
2. Rise in INR: A > 0.4 rise in INR in less than 48 hours
3. Old INR: An INR has not been recorded in the last 48 hours

Aminoglycoside Dashboard
1. No SrCr: No serum creatinine result available
2. Old SrCr: No serum creatinine result within the last 24 hours
3. No AG Level: No aminoglycoside drug level available
4. Old AG Level: No aminoglycoside drug level within the last 72 hours
5. Rise in SrCr: A ≥ 0.3 mg/dL rise in serum creatinine in less than 48 hours
6. Drop in SrCr: A ≥ 0.3 mg/dL drop in serum creatinine in less than 48 hours.

Heparin/Enoxaparin Dashboard
1. Old PTT: No partial thromboplastin time (PTT) within the last 12 hours
2. Platelet Drop: The current platelet count is < 150,000 per microliter and has been reduced by at least 50% in the last 48 hours
3. No PTT: No PTT available for patient on heparin infusion
4. CrCl < 30: Estimated creatinine clearance is < 30 mL/min for patient on enoxaparin
5. HIT: A positive laboratory result for heparin-induced thrombocytopenia
6. Infusion rate > 2500: The heparin infusion order has a rate > 2500 units/hour
7. Heparin Bolus > 10000: The patient has received a heparin bolus > 10000 units.

1. The percentage of study days a dashboard was viewed by a pharmacist

2. The percentage of patients actively "checked" by a pharmacist

3. The number of distinct cases and views for the patient-level detail screen

4. The number of pharmacy comments generated

Pharmacist Interventions. Finally, to evaluate interventions made by the pharmacists, we performed a qualitative analysis of comments generated for 100 randomly selected patients from each dashboard. For each comment, we determined whether it documented demographics, comorbidities, and indication; reported orders and administrations; summarized laboratory values and trends; reminded later viewers about continued pharmacy monitoring; or elaborated interventions.

Results

Patient Population

There were 28,929 adult inpatient admission and observation encounters during the 183-day study period, with an average daily census of 576 cases. The proportion of cases with a positive alert relative to the number of cases exposed to the drug are shown in Table 2 (page 329). The most common alerts occurred on the aminoglycoside dashboard and concerned missing or delayed monitoring of serum creatinine.

Dashboard Coverage and Utilization

Drug exposure, coverage, and utilization for the three dashboards are shown in Table 3 (page 329). A total of 51 pharmacists used the dashboards: 30 used the warfarin, 23 the aminoglycoside, and 21 used the heparin/enoxaparin dashboards. Coverage for the warfarin and aminoglycoside dashboards was excellent, with use occurring every day during the study period. The heparin/enoxaparin dashboard was covered for 71% of study period days. Responsibility for the aminoglycoside dashboard appeared to be distributed, with three reviewers using the tool for a total of 86, 75, and 60 days, respectively. The warfarin and heparin/enoxparin dashboards each had one predominant pharmacist reviewing cases (120 and 96 days, respectively). All dashboards were predominantly checked between 7:00 A.M. and 3:00 P.M.

Utilization Patterns. Utilization patterns differed among the three dashboards. For warfarin, fewer than half of the cases required a detailed case review, but those cases were reviewed an average of four times each. All patients receiving aminoglycosides were reviewed at least once with the detailed patient page (Appendix 3), with an average of eight reviews per case. Detailed review of patients receiving heparin/enoxaparin occurred in fewer than 5% of the cases. Use of the checked feature for interpharmacist communication ranged from 100% of aminoglycoside cases, 32% of warfarin cases, and 4% of heparin/enoxaparin cases. Similarly, generation of pharmacy comments varied from 100% of aminoglycoside cases (more than three comments per case), 50% of warfarin cases, and only 3% of heparin/enoxaparin cases.

Pharmacist Interventions

Pharmacy use of the dashboards led to numerous patient safety-related interventions, such as notifying the clinical team about suboptimal medication orders, incorrect drug dose adjustments, or inadequate monitoring. We reviewed 661 comments for 100 randomly selected patients from each dashboard (176 warfarin, 369 aminoglycoside, and 116 heparin/enoxaparin pa-

Table 2. Frequency of Adverse Drug Event Dashboard Alerts in a Six-Month Study Period*

Dashboard	No. of Patients Exposed to Drug	Alert Name	Cases with Alerts	Percentage of Eligible Patients with Alert
Warfarin	2,224	High INR	294	13%
		Rise in INR	557	25%
		Old INR	304	14%
Aminoglycosides	869	No SrCr	480	55%
		Old SrCr	469	54%
		No AG Level	23	3%
		Old AG Level	114	13%
		Rise in SrCr	132	15%
		Drop in SrCr	143	16%
Heparin/enoxaparin	8,383	Old PTT	646	8%
		Platelet Drop	379	5%
		No PTT	903	11%
		CrCl < 30	94	1%
		HIT	21	0.3%
		Infusion Rate > 2,500	30	0.4%
		Heparin Bolus > 10,000	14	0.1%

* INR, international normalized ratio of prothrombin time; SrCr, serum creatinine; AG level, aminoglycoside drug level; PTT, partial thromboplastin time; CrCl, estimated creatinine clearance rate in milliliters per minute; HIT, heparin-induced thrombocytopenia.

Table 3. Drug Exposure and Pharmacist Utilization of Adverse Drug Event (ADE) Dashboards in a Six-Month Period

Dashboard	No. of Patients Exposed to Drug	Typical Daily Census	Unique Cases Reviewed (No. of Reviews)	Percent Days Viewed	Percent Patients' Reviewed in Detail	Comments Created by Pharmacists
Warfarin	2,224	54	1,010 (4,335)	100%	32%	1,186
Aminoglycosides	869	18	869 (7,503)	100%	100%	2,825
Heparin/enoxaparin	8,383	54	394 (675)	71%	4%	259

tient comments).

Warfarin. Comments generated for patients on the warfarin dashboard frequently summarized orders and recent laboratory trends and described changes to care that had already been made by the providing team. Many of the comments served as reminders for monitoring of later international normalized ratio (INR) values, which had been ordered but not resulted. For example, in one case, a newly admitted patient had an evening warfarin order but the INR hadn't yet been drawn, resulting in a "no-INR" alert.

Aminoglycoside. For the aminoglycoside dashboard, comments were detailed, frequently summarizing patient, order, and laboratory data. Pharmacists frequently described interventions by recounting that the provider contacted and summarizing recommendations, including continued monitoring of serum creatinine or therapeutic drug levels, modified dosing of existing medications, or discontinued orders for medications that were no longer needed. Pharmacists using the aminoglycoside dashboard were also more likely to author pharmacy recommendations into the EMR.

Heparin/Enoxaparin. Comments from the heparin/enoxaparin dashboard most often summarized current orders and laboratory trends but also described interventions made by the pharmacist. Unlike comments from the aminoglycoside dashboard, which elaborated on detailed recommendations, these comments usually included notification of the provider about increasing partial thromboplastin time (PTT) without specific advice for changing therapy.

Discussion

The real-time surveillance tool successfully synthesizes data in real-time, prioritizes patients on the basis of predefined clinical

data rules, and facilitates pharmacist-to-pharmacist and pharmacist-to-clinical team communication. In a health care system where each of the dashboard medications already relied on advanced initial dosing decision support during the time of this study, our initial experience with implementation shows a high rate of use and need, with frequent monitoring (100%) for warfarin and aminoglycosides (but not heparin/enoxaparin), and a substantial number of care interventions by clinical pharmacists.

Dashboard Utilization and Coverage

Monitoring of heparin and enoxaparin was a new requirement for pharmacy staff, which may explain the lower coverage for this dashboard. Discrepancies in utilization between the warfarin and aminoglycoside dashboards may be due to differences in work flow, triggering events, and maturity of monitoring. The aminoglycoside dashboard was the first tool developed and complemented a well-established therapeutic drug monitoring service. Its dashboard appeared to be used to validate and share comments across pharmacist's daily reviews for almost every patient's aminoglycoside dose, while patients on the warfarin and heparin/enoxaparin tools were typically reviewed only when an alert was present on the dashboard. Whereas the warfarin dashboard alerts on only three triggers, the aminoglycoside dashboard alerts on six triggers. The aminoglycoside dashboard also displayed a large number of inactive orders, which were held because of high drug levels, and timing of active dialysis therapy did not always correspond with daily orders; these scenarios may not have been as easily identified from the dashboard view as those for warfarin. In addition, the pharmacy kinetics service policy required a progress note to be written when an aminoglycoside drug level resulted but not when an INR is measured following warfarin administration.

The aminoglycoside dashboard was helpful in identifying patients for whom renal function estimation was not available or was outdated. An advanced clinical decision support system had been implemented for dosing and monitoring of aminoglycoside therapy before implementation of the dashboard; however, the dashboard made the pharmacist aware of scenarios in which patients were dosed on the basis of estimated or unavailable renal function data and allowed follow-up, which is critical in avoiding nephrotoxicity with aminoglycoside therapy. The warfarin dashboard alerted on the "Rise in INR" most frequently, allowing pharmacists to quickly intervene when a rising INR was predicted to overshoot the target range, thereby preventing or reducing the severity of a supratherapeutic level. The presentation of corollary orders, such as interacting drugs, allows easy identification and correction of such conditions that are not easily identifiable in the standard clinical systems work flow. This early intervention and dose optimization by the pharmacist may prevent a patient from later receiving a "High INR" alert. The heparin/enoxaparin dashboard was most helpful in triggering on the "needles in the haystack" for safety and monitoring, as so many patients were exposed to these medications. However, some of the triggers were false positives, such as the appearance of the "No PTT" alert as soon as the heparin was ordered. As a result, identifying heparin-induced thrombocytopenia, changes in renal function on enoxaparin therapy, and very high dosing became the focus for this dashboard.

Interventions and Pharmacy Comments

Like the utilization outcomes, use of the comments and interventions varied across the three dashboards. Use was similar in that all dashboards included comments about laboratory trends (for example, "SrCr [serum creatinine] back to baseline" and "Platelet drop before enoxaparin"). All dashboards also included identification of patients who no longer needed to appear on the dashboard (for example, "Heparin d/ced" and "No active order for warfarin at this time"). The significantly higher use of descriptive interventions and comments in the aminoglycoside dashboard was likely due to the fact that there was a well-established therapeutic drug monitoring consult service available for these drugs. This consult service preceded the pharmacy surveillance initiative, had well-established processes for coverage and review, and was the primary customer during the dashboards' development. Comments on the heparin dashboard also seemed to explain false-positive alerts (for example, "PTT ordered"), which commonly appeared.

Dashboard Design and Implementation

In current form, the surveillance tool is organized by drug class to match the work flow of a specialty clinical pharmacist. Pharmacists responsible for therapeutic drug monitoring conducted aminoglycoside surveillance, and the pharmacist expert in anticoagulation conducted warfarin surveillance. As the use of surveillance dashboards expands, the organization of the tool may need to be modified to present a variety of high-risk conditions across the panel of patients covered by a unit-based or rounding team-based pharmacist.

Constructing a dashboard usually requires more precise rules than are typically provided in the research literature or accreditation agency guidelines. For example, INR alerts on the warfarin dashboard warned about values outside the target range and values rising by 0.4 in a 48-hour period instead of warning

only about supratherapeutic values. Tuning alerts and enrollment criteria to adjust sensitivity and specificity are essential for successful adoption of the dashboards. Inclusion of visual cues and opportunities for feedback is also desirable. Simple techniques to show which dashboards and patients have been reviewed and visualization of interpharmacy communications through mouse-over hovering on the summary page were well-received. A real-time surveillance tool that is integrated into the EMR with sufficient audit logs also increases transparency and may reduce the need to subsequently document pharmacy interventions.

We found that our early attempts to improve care with retrospective reviews of potential ADEs were less productive than the current efforts at real-time surveillance. Retrospective review occurred outside existing work flow and was seen as extra work with limited benefit. With most patients having a short length of stay, retrospective review often highlighted potential ADEs in patients who had already been discharged. Pharmacists preferred an early warning that allowed intervention before patients suffered an ADE. Achieving the strategic goal of medication error reduction required pre-empting ADEs by developing a "rapid response" system. The team's experience with CDS system development and implementation suggested that ADE reduction (above and beyond what is achieved by CPOE and basic decision support) is difficult with a purely technology-driven approach. We observed that complex patient care required a multimodal, data-driven, team approach to correct risk-producing conditions before they were propagated downstream. Inspired by previous research that compared CPOE and clinical pharmacist interventions,[21,22] our approach complements existing CPOE with computer-assisted clinical pharmacist surveillance.

Limitations

The common infrastructure in the real-time surveillance tool is adaptable to other high-alert medications; however, use of the tool on a daily basis required significant adjustment of staffing and work flow for clinical pharmacists. Although we were able to describe some interventions made by the pharmacists through qualitative analysis of the dashboard comments, our results were limited in that some interventions may not have been included in the comments, and we have no measures of whether all recommended changes were made by the providers. Because use of the comments varied by pharmacist user, we also could not determine the absolute frequency at which interventions occurred. We have not yet measured the clinical impact of the tool on medication errors or ADEs. Finally, the work was done at a single institution, and replication requires a significant and accessible information technology infrastructure. However, others have implemented a commercial application with similar objectives in community hospitals[23] and nursing homes.[24]

Future Directions

Although current reported research has described ADE surveillance in adults, there are implications for multiple potential applications and clinical audiences. For example, pediatric pharmacists are currently being engaged at VUMC to improve the use of anticoagulants. Infection control teams could use a dashboard that takes advantage of newly available structured microbiology reports to help meet Joint Commission National Patient Safety Goals regarding the prevention of health care–associated infections, such as *Clostridium difficile* and methicillin-resistant *Staphylococcal aureus* (MRSA).[6] Specialty pharmacists or clinicians could monitor complex drug-disease interactions that commonly occur with chronic kidney disease or liver failure.

As ADE detection migrates to pre-emption, an organization's overall medication safety effort may evolve toward monitoring goal-directed therapy. Clinical pharmacists can leverage surveillance tools to expand the scope of their practice and improve the speed at which they react to potential ADEs; they can collaborate with the primary team to enhance therapy optimizations and with informatics personnel to improve CDS. At VUMC, collaboration has improved warfarin dosing through explicit definition of target-range goals and optimized aminoglycoside dosing through pharmacokinetic modeling that enables avoidance of renal failure while achieving therapeutic target drug levels. Continued surveillance of high-risk patients through improved data aggregation and visualization should allow pharmacists to increase specificity above existing CDS with automated rule-based alerts for complex conditions. J

Online-Only Content

See the online version of this article for

Appendix 1. Summary Page of All Potential Adverse Drug Event Dashboards

Appendix 2. Aminoglycoside Adverse Drug Event (ADE) Surveillance Dashboard

Appendix 3. Warfarin Patient View

Appendix 4. Corresponding Warfarin Graph of Prothrombin Time (PT-inr) Trend, Warfarin Dose Adjustments, and Therapeutic Goal Specified by the Order

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Online-Only Content

Appendix 1. Summary Page of All Potential Adverse Drug Event (ADE) Dashboards

All ADEs

(Logout)

VUH Views	Num Patients	Last Checked	By
Heparin-Enoxaparin	50	2009-10-26 07:19:57	johnco6
Insulin	220	2009-02-28 10:25:35	dort8jn
Endocrine patients (Insulin View)	16	2008-11-26 11:15:04	danc4j6
Warfarin	45	2009-10-26 14:59:28	pennowr
Aminoglycosides	16	2009-10-25 14:17:56	pennowr
VANC	103	2009-08-26 19:13:29	edmo6qw
VCH Views			
Heparin	2	2009-10-27 15:18:47	hilluq2
Enoxaparin Peds	7	2009-10-27 15:17:55	hilluq2
Aminoglycosides	43	Never	None
Insulin	8	2008-10-29 16:12:35	halprw3
Warfarin	2	2009-10-23 06:56:45	hilluq2
Synagis	0	Never	None
Development Views			
All Patients	271	Never	None
AKI	10	Never	None
CDIFF	11	2009-02-24 15:25:55	danc4j6
Geriatric	62	2009-07-14 17:43:27	waitazi

The summary page displays the number of patients currently exposed to each medication class and the most recent time a dashboard was indicated as "checked" by a user. VANC, vancomycin; peds, pediatrics; AKI, acute kidney injury; CDIFF, Clostridium difficile.

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Appendix 2. Aminoglycoside Adverse Drug Event (ADE) Surveillance Dashboard

Aminoglycosides

(Back | All ADEs | Logout)

This Page Last Checked
2009-03-06 14:50:58

Alerts	Act	Com	Last Checked	Name	Height (in)	Weight (kg)	Age	Service	Unit	Room	Recent Drugs	Dose (mg)	Frequency	Latest Drug Level (ug/mL)	Time	SrCr (mg/dL)
RISE IN SrCr	A	C	2009-03-07 13:59:57		65	100.0	80	NEU	5S	5203X	Gentamicin	130.0	Q24H	NA	NA	2.62
OLD AG LEVEL DROP IN SrCr	A	C	2009-03-06 13:31:32		66	128.6	56	EGS	3N/C	3006X	Tobramycin	220.0	Q24H	0.8	2009-03-02 08:00:00	3.21
OLD AG LEVEL	A	C	2009-03-07		66	131.0	71	PUL	7SMI	7205X	Amikacin	750.0	Q36H VAR	22.0	2009-03-03 12:39:00	1.23
NO SrCr	A										amycin	550.0	Q24H	NA	NA	NA
NO SrCr	A										tamicin	90.0	ONCE	NA	NA	NA
NO SrCr											tamicin	500.0	ONCE	NA	NA	NA
DROP IN SrCr			07:55:29								Gentamicin	300.0	ONCE	7.1	2009-03-06 02:00:00	1.29
DROP IN SrCr		C	2009-03-07 07:58:31		67	93.0	55	NEU	5S	5218X	Gentamicin	220.0	Q24H	NA	NA	1.21
	A		-NEVER			101.0	49	NEP	10S	10212	Gentamicin	60.0	ONCE	NA	NA	8.17

2009-03-07 13:29:09 ( ) **TDM Consult** Only 2 doses left – Continue current regimen. || 2009-03-06 14:50:10 ( ) **TDM Consult** continuing current dose 750mg q36hrs this weekend no more levels as only 2 doses remaining unless change in conidtion warrants levels. || 2009-03-05 13:08:48 , *TDM Consult* first dose 750mg q36 3/4 2100 – watch SCr. || 2009-03-03 14:22:13 ( ) *TMD Consult* increased to 750mg q36hrs starting 3/4 || 2009-03-01 13:32:27 ( ) ***TDM Consult Pt*** see starpanel note 2/28 amik 625mg q36 (7mg/kg) peak/trough due 3/3 || 2009-02-28 11:14:20 ( ) ***TDM Consult Pt*** see starpanel note 2/28 amik 625mg q36 (7mg/kg) peak/trough due 3/3 ||

In this screenshot of the aminoglycoside dashboard, which displays all patients with an active order for an aminoglycoside (gentamicin, tobramycin, or amikacin), alert conditions are shown in the left-most column. A pop-up window caused by mouse-hovering over patient record is shown. SrCr, serum creatinine; Com, comments; NEU, neurology; EGS, emergency general surgery; PUL, pulmonary; NEP, nephrology; Q24H, every 24 hours.

Online-Only Content

Appendix 3. Warfarin Patient View

Warfarin Patient Information

(Back | All ADEs | Warfarin Patients | Launch WebWiz | Logout)

This Page Last Checked: 2009-03-07 10:13:54 — Update Last Checked Time

Name:		Age: 85	Sex: M	Weight: 89.993	Height: 0
Service: GMD	Unit: S74	Room: 7436X	Updated: 2009-03-07 21:25:38	Case	

LAST ORAL DOSE (MG): 2.5	FREQUENCY: QBEDTIME
PT-inr: 3.7	ACTIVE SS: NA
ALERTS: HIGH PT-inr	UPDATED: 2009-03-07 21:25:38
INTERACTIONS: Fluco	

Graph

Relevant Orders

Order Description	Lab Value	Comment	Start	Stop
PT-inr	3.7		2009-03-07 04:30:00	
Hgb	9.2		2009-03-07 04:30:00	
PCV	30.0		2009-03-07 04:30:00	
WARFARIN: 2.5 MG PO QBEDTIME		TARGET INR 2-3;	2009-03-06 13:04:00	2009-03-06 07:27:00
WARFARIN: 3. MG PO QBEDTIME		TARGET INR 2-3;	2009-03-06 11:24:00	2009-03-05 13:04:00
PT-inr	4.8		2009-03-06 04:50:00	
Hgb	7.4		2009-03-06 04:50:00	
PCV	24.0		2009-03-06 04:50:00	
FLUCONAZOLE 1.0 TAB 200 MG		U	2009-03-05 10:56:00	
FLUCONAZOLE: DIFLUCAN 200. MG PO Q48H			2009-03-05 07:50:00	2009-03-05 10:44:00
PT-inr	3.3		2009-03-05 02:30:00	
Hgb	7.8		2009-03-05 02:30:00	
PCV	26.0		2009-03-05 02:30:00	
WARFARIN: 4. MG PO QBEDTIME		TARGET INR 2-3;	2009-03-04 22:00:00	2009-03-05 11:23:00
WARFARIN SODIUM 1.0 TAB 4 MG		U	2009-03-04 21:52:00	
PT-inr	2.4		2009-03-04 03:45:00	
Hgb	8.1		2009-03-04 03:45:00	

Previous Pharmacy Comments

2009-03-07 10:13:53
INR down from 4.8 --> 3.7 today, warfarin order continues to be d/c. Will watch for new order.

2009-03-06 09:49:25

Pharmacy Comment Box

Previous Star Comments

2009-03-06 10:17:30
Re-evaluating due to fluconazole being resumed as have been in consultation for warfarin dosing suggestions with multiple interacting antibiotics and poor po

Star Comment Box

From either the dashboard or patient view, the reviewer can flag panels or patients as "checked" by clicking the "This Page Last Checked" cell in the upper right or the "Last Checked" cell for each patient's record. The "checked" feature was used to denote that the patient's case was reviewed in detail that day. Its indicator color turns green when clicked and resets to red the next morning. SS, sliding scale insulin order; NA, not applicable; ADE, adverse drug event; PT-inr, prothrombin international normalized ratio; d/c, discontinued; Hgb, hemoglobin; PCV, packed cell volume; PO, orally; poor po, poor oral intake. (See *Appendix 4.*)

Online-Only Content

Appendix 4. Corresponding Warfarin Graph of Prothrombin Time (PT-inr) Trend, Warfarin Dose Adjustments, and Therapeutic Goal Specified by the Order